KOREAN STYLE SMART FARM FOR PLASTIC GREENHOUSE

Sang-Cheol Kim¹,
Hyeon-dong Lee¹, and Jae-Soo Lee¹
¹ National Institute of Agricultural Science, Jeonju, Korea
e-mail: sckim7777@korea.kr

ABSTRACT

Many futurists and research institutes have begun discussing the prospects for the Fourth Industrial Revolution and future social change. And they have set up various strategies and policies at the government level to preemptively prepare for future changes and to lead the future society. The technological core of the Fourth Industrial Revolution, which has come to the fore as an opportunity and a threat to agriculture, is convergence. The cyber world, the physical world, and the biological world are networked, and artificial intelligence, robots, IoT and augmented reality technologies converge to provide completely different industrial production and services.

In agriculture, much of the physical labor will be replaced by automation and smart technology, which will lead to many changes in the agricultural industry. In farming machines, the needs of human manipulation or skillful functions are minimized by the application of robot technology such as autonomous navigation. Farming machines and tools for small-scale farming are used by aged farmers or women farmers. And IoT sensors for health care that are more simple and lighter will be utilized to diagnose workload and health of farmers.

Korea’s smart farm technology development project is a so-called futuristic agriculture system that combines artificial intelligence, IoT, big data analysis and cloud service technology, robots and automation technology, which are key technologies of the fourth industrial revolution. The goal of the project is to overcome the weaknesses of Korean agriculture and to improve the international competitiveness of agriculture base and to develop the next generation agricultural system that can be used by the world.

Through the smart farm, it is possible to overcome the limitations of existing agriculture, to enable new production revolution such as adjusting the growth rate of crops according to market conditions, and to attract young people to be engaged in agriculture and go back to the rural areas. It is hoped that it will help in job creation and agricultural problem of Korea and help solve problems like the aging population, labor shortage in the rural area.

Keywords: Agricultural System, Smart Farming System, Technology Convergence,

4TH INDUSTRIAL REVOLUTION AND SMART FARM TECHNOLOGY TREND

Recently, the 4th industrial revolution is characterized by hyper-connectivity and intelligence. This revolution has shown rapid pace of technological development, and many changes are taking place not only in technology and industry, but also in our daily lives. The key theme of the Korean government’s business report in 2017 was to find a preemptive countermeasure in the era of the Fourth Industrial Revolution.

In human history, the emergence of new technologies and technological innovations has been going on forever. The Fourth Industrial Revolution is a new paradigm of industry and technology led by convergence of information and communication technology (ICT), artificial intelligence, robot technology, and life science technology.

The first mechanization industry revolution, which was invented as a new power system represented by steam engine in the 1780s. The second electrification industry revolution, which brought mass production innovation of industrial by combination of power and electric system in the 1870s. Following the revolution of tertiary IT industry led by automation production system by the spread of computers and internet in the 1970s. Technology that combines ICT, robot, and AI such as cyber physical system (CPS) integrates reality and virtual world, the era of the 4th intelligent industrial revolution, which automatically and intelligently controls services, is beginning.
The biggest technical feature of the 4th Industrial Revolution is the hyper connection by data technology (IoT, Cloud, Big Data, Mobile) and entry into super intelligent society by artificial intelligence. In 2016, we have already experienced the power of artificial intelligence and the super intelligent society in the game against ‘AlphaGo’, an artificial intelligence computer. Unlike the prospect that humans would prevail, ‘Alpha Go’ wins by learning game theory and precise probability calculations. This confrontation has led many to begin to pay attention to artificial intelligence and future social change, and finally to declare the beginning of the Fourth Industrial Revolution.

Smart Farm is a new paradigm of agriculture where many core technologies of the Fourth Industrial Revolution are merged. Subjective and abstract farming techniques that depend on the farmer's experiences and senses are quantified and objectified based on sensor and network technology. The expertise of decision making and agricultural work, which has been made by repeated trial and error and personal know-how, is intelligent and automated by computer and artificial intelligence.

When a computer or a smart phone is connected to the Internet, it is possible to observe changes in the farming environment occurring on the farm at anytime, anywhere, without any restriction of time and place, and to precisely control and manage the remote area far away. The world recognizes Smart Farm, which is a fusion of ICT technology, as a future model of agriculture. In order to cultivate Smart Farm as a growth industry, each country is competing for technology development in a close strategy.

**STATUS AND POLICY OF SMART FARM TECHNOLOGY DEVELOPMENT IN KOREA**

The Korea Rural Development Administration (Korea RDA) has selected the Korean smart farm model and the complete localization and standardization of related parts as the priority tasks. In order to develop a smart farm model suitable for agricultural conditions in Korea and to make the whole process of agricultural production system more smart, we are concentrating on researching smart farm basic technology and related ICT devices. In particular, smart farm software and contents-oriented technologies are being promoted along with hardware. Development of smart farm models is progressing step by step according to the level of applied technology. The first-generation of smart farm model was developed for the purpose of improving farming convenience. The second generation model is improving crop productivity, and the third generation model is being developed for the purpose of global industrialization of a greenhouse plant model. Through the phased development and commercialization plan of smart farm technology, it is planned to reduce the use of labor force and farm materials, increase farmers' income by improving productivity and quality, and solve the problems of agriculture field and related industry at the same time.
In 2015, the RDA proposed a first-generation Korean smart farm model suitable for single spans and multi-span plastic greenhouses, which account for most of the Korean greenhouses. The first-generation smart farm is a remote management system that can monitor and regulate the growth environment of crops by the Internet, wired and wireless communication, and was developed to improve farmers' working convenience. The first-generation of smart farm contributed greatly to the improvement of the quality of life by freeing farmers who were tied up in time and place for agricultural work such as greenhouse environmental management. The primary technology of the first-generation smart farm is to redesign the farm automation and ICT technologies developed so far to match the horticulture farm, and to present the standardized model by dividing it into the basic type and the optional type, which is selected according to the needs of the farm.

The Korean government (Korea Ministry of Agriculture, Food and Rural Affairs) is promoting the transition to capital and technology intensive agriculture with the enhancement of international competitiveness by overcoming vulnerability of agriculture through the spread of Korean smart farms. The total area of facilities for horticultural agriculture in Korea is about 52,000 hectares, which has been stagnant since 2000, but the area of small greenhouses is decreasing, while the number of large greenhouses larger than 1 ha is increasing. The Korean government plans to upgrade 4,000ha, which is 40% of the greenhouse area (10,500ha) motorized by 2017, to the smart greenhouse in conjunction with the modernization project for horticultural facilities.

DEVELOPMENT DIRECTIONS OF THE NEXT GENERATION OF KOREAN SMART FARM

The first-generation smart farms reduced the labor force by improving the convenience of farming, and free farmers from the time and space constraints of farming. However, the second generation smart farm aims to improve the productivity and quality of agriculture by automating precise crop growth management. The core technologies of the second-generation smart farm, which can be called the smart farm technology in the true sense, include technology for measuring growth information that can automatically measure and collect crop growth status and biometric information, and large data utilization techniques that control precise environmental management conditions required at the production stage by predicting harvest time, yield, and quality from environmental information and growth models.

Since 2014, the Rural Development Administration has been progressing the development of growth models of several crops such as tomatoes and chrysanthemums. In 2016, we have developed a growth model to forecast the growth and yield of ripe tomatoes in Europe. We plan to develop chrysanthemum, paprika and strawberry growth models starting from tomatoes until 2019.

In addition, in 2016, we developed an intelligent plant growth information measurement system that can measure plant height, number of leaves, leaf area, stem diameter, and number of fruits using images of tomato plants. We have developed a microsensor for the measurement of plant biomedical information, which can be used for plant stress, growth state diagnosis and quality prediction by inserting electrodes into plant stem to measure plant biomechanical reaction.
The representative difference between the smart greenhouse and the conventional automated greenhouse are the big data processing technology that makes effective use of the measurement data and the technology that links the analyzed result to the greenhouse environmental control system. As a result of evaluating the effectiveness of the smart greenhouse by standardizing the measurement data and applying it to the demonstration farm, the tomato farming demonstration farm showed a high effect of 44% productivity improvement and 50% reduction in labor force. In the future, more and smarter farm empirical studies are being conducted in demonstration farms by region and by crop type to analyze effects and direction in Korea.

In addition to the 1st generation of smart farm, there are virtual reality-based open simulator technology to optimize smart farm's energy and environment, agriculture work history and safety management technology for agricultural products using Internet of things, automatic diagnosis technology of crop pests and nutritional status using artificial intelligence and image processing, cloud-based intelligent smart farm integrated control technology are being actively researched as key technologies that will form the next generation of Korean smart farms.

The Rural Development Administration plans to open up the era of Korean smart farms through the second generation model that is an intelligent optimal growth management technology. This can be done by combining key smart farm technologies by 2018. The Korean smart farms will be developed based on the standards and have industrial compatibility and scalability through an open platform that not only includes hardware but also software.

**FUTURE PROSPECT AND IMPLICATIONS OF SMART AGRICULTURE**

The technical characteristics of the Fourth Industrial Revolution which include ICT, artificial intelligence, robots, big data, and internet of things (IoT) will greatly change the appearance of future agriculture and farming conditions. It can be a natural course of smart farm technology to prepare the future and to pioneer the future of Korea agriculture through the development of scientific farming technology.
The Internet of Things (IOT) technology, where everything is connected to the Web in real time, will be applied across the industry. Cloud computing technology, which uses IT as a service in the form of using electricity at home, is becoming common. As the lifestyle and working styles of individuals, such as smart work and u-health, are changing, new changes are beginning to take place throughout agriculture and its related industries.

In the sector of agricultural production, ubiquitous farms and smart farmers emerge. Smart farm systems are established to acquire all the information necessary for the farming process in real time. Even if farming knowledge is low, artificial intelligence computer provides customized consulting and technical information to suit farmers' level and farming environment, and intelligent and robotic farming makes farming more efficient and comfortable.

In the sector of agricultural products distribution, smart auction, social network service using smart phone, direct transaction of farmers and consumers through smart TV, and joint purchase of agricultural commodities by social commerce will become a new distribution order. With smart devices that evolve into more diverse forms, consumers will form a new distribution structure that will enable them to purchase agricultural products with confidence on-line without going to the off-line market.

In the consumption sector, producers and consumers will reduce distance and build trust by exchanging information on traceability information and quality and safety of agricultural products that can automatically be added by IoT equipment in the production and distribution process of agricultural products.

In order for smart farm technology to be effectively spread to farming sites, it is also necessary to prepare an industrial base and institutional arrangements. First, the technologies and products that make up the smart farm should be stable. An agriculture ICT system of smart farm that can produce reliable data continuously even in a harsh environment should be established. Agricultural ICT components and equipment should be standardized, and the system should be modularized to allow farmers to choose smart farm equipment based on crop types and farming conditions. Institutional arrangements should be made to supply the better smart farm products and services to agriculture, including the establishment of a certification system that only good quality ICT products and services are supplied to farming sites.

And most importantly, it is human resources. In order for smart farms to settle well in agriculture, to bloom technology and bear fruit, young human resources with skills and passion must be prepared. No matter how good a tool is, if it cannot be used, it will be an obstacle to farming. Agriculture will be the most important and promising industry on the planet when the best people create smart foods and services for the human race.

For the future of the newly developed agriculture, the government must prepare the necessary hardware and software infrastructures for smart agriculture and laws and systems to support the smart age. Thetelecommunications infrastructure, which is built mainly in urban areas, should be expanded so that farmers can access the Internet easily and cheaply at farming sites. The hardware infrastructure of smart agriculture needs to be constructed so that the service range of electric power and wireless internet network can be used in all rural areas.
As a software infrastructure, farmers should be able to quickly and easily retrieve and utilize the necessary information on agricultural information databases. The government should also consider constructing an agricultural cloud service system as a next-generation of agricultural infrastructure so that big data can be made more effective for farming through artificial intelligence analysis tools.

In terms of legal and institutional aspects, the agricultural use of smart devices is increasing, and institutions and laws need to be improved to support new distribution methods that utilize social networks, IPTV, and social commerce not only in agricultural products production but also in consumption and distribution. For example, in the quality certification of agricultural ICT equipment and services, in the protection and sharing of information, in the protection of personal information contained in agricultural data, in the indication of origin of agricultural products that are directly traded, in quality grading. Laws and regulations that support them in producers and consumer protection against deterioration need to be established to fit the smart agricultural system.

Successful results of these efforts will be the basis for realizing smart farms in the agricultural field in the future, and agriculture can become a new growth axis that drives the economy of the country. And agriculture can play a key role as an economic power to produce quality jobs and industrial services.

REFERENCES

Korea RDA, 2015, Korean Smart Farm Development Direction and Strategy Symposium
Korea Ministry of Agriculture, Food and Rural Affairs, 2015, Measures to Spread Smart Farm
Korea Ministry of Agriculture, Food and Rural Affairs, 2016, Measures to Accelerate Smart Farm Expansion
NIAS of Korea RDA, 2016, International Symposium on Smart Farm Industrial Strategy
NIAS of Korea RDA, 2015, Driver Interface for Smart Greenhouse (TTAK.KO-10.0845)
NIAS of Korea RDA, 2016, Sensor Interface for Smart Greenhouse (TTAK.KO-10.0903)
NIAS of Korea RDA, Smart Imaging Device for Smart Greenhouse (TTAK.KO-10.0945)